

PROCEEDINGS

OF

THE ROYAL SOCIETY.

June 6, 1867.

The Annual Meeting for the election of Fellows was held this day.

Lieut.-General SABINE, President, in the Chair.

The Statutes relating to the Election of Fellows having been read, Major-General Boileau and Mr. J. Clerk Maxwell were, with the consent of the Society, nominated Scrutators to assist the Secretaries in examining the Lists.

The votes of the Fellows present having been collected, the following Candidates were declared to be duly elected into the Society :—

William Baird, M.D.
W. Boyd Dawkins, Esq.
Baldwin Francis Duppa, Esq.
Albert C. L. G. Günther, M.D.
Julius Haast, Esq., Ph.D.
Capt. Robert Wolseley Haig, R.A.
Daniel Hanbury, Esq.
John Whitaker Hulke, Esq.

Edward Hull, Esq.
Edward Joseph Lowe, Esq.
James Robert Napier, Esq.
Benjamin Ward Richardson, M.D.
J. S. Burdon Sanderson, M.D.
Henry T. Stainton, Esq.
Charles Tomlinson, Esq.

June 20, 1867.

Lieut.-General SABINE, President, in the Chair.

Dr. William Baird, Dr. Günther, M.D., Capt. R. Wolseley Haig, Mr. Daniel Hanbury, Mr. Whitaker Hulke, Mr. Edward Hull, Mr. Edward J. Lowe, Dr. B. Ward Richardson, Dr. J. S. Burdon Sanderson, Mr. Henry T. Stainton, and Mr. Charles Tomlinson, were admitted into the Society.

VOL. XVI.

B

In accordance with the Statutes, notice of the ensuing Anniversary Meeting for the election of Council and Officers was given from the Chair.

The following communication was read:—

- I. “Description of an Apparatus for the Verification of Sextants designed and constructed by Mr. T. Cooke, and recently erected at the Kew Observatory.” By BALFOUR STEWART, LL.D., Superintendent of the Kew Observatory. Received May 9, 1867.

In order to test the accuracy of graduation of a sextant, it is necessary to have a series of well-defined objects, the angular distances between which must be accurately known. The sextant under trial is made to measure these angular distances; and the results thus obtained, when compared with the correct values of these distances (supposed to be otherwise determined), will give at once the error of the instrument.

Now with regard to this series of objects, the following conditions are necessary in order that they may be convenient for the purpose of testing sextants:—

- α. It is necessary that the objects should be distinctly seen and well defined. Luminous objects would be preferable, if these could be obtained. Luminous points would answer well.
- β. It is necessary that they should be at a very great, or virtually infinite distance from the sextant, so that two lines proceeding from any point in the objects, the one to the index-glass, and the other to the horizon-glass, should be virtually parallel to each other.
- γ. It is necessary that these objects should be at such angular distances from one another, that by means of them it may be possible to test, say every 15° of a sextant's arc.
- δ. It is necessary that these objects should be always visible, or at least that they should be rendered visible easily, and without loss of time.

A series of fixed stars, at suitable intervals from one another, might be made to fulfil the first three of these conditions; but in this uncertain climate it would be inconvenient to adopt any mode of verification depending for its success upon the visibility of the sun or stars;—in fine we must have a source of light which can always be commanded.

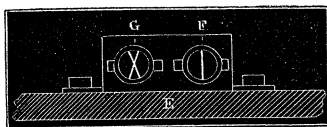
A plan proposed by Mr. T. Cooke fulfils this requirement, and as it has now been carried out with apparent success, a short description of it may perhaps be acceptable to the Royal Society.

His arrangement is of the following nature:—

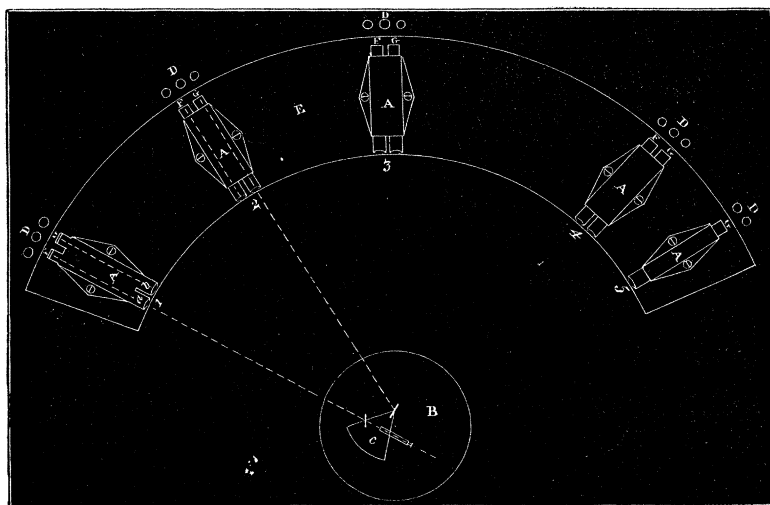
F, G denote two collimators, F having a single vertical line, and G a couple of cross lines, as shown in the figure.

The collimator F is at the principal focus of the lens *a*, and the collimator G at that of the lens *b*.

Elevation of Collimators, showing wires viewed from outside the circle.



Plan of Cooke's Apparatus for Verifying Sextants at the Kew Observatory.



- A. Double collimators.
- B. Table for holding sextants.
- C. Sextant.

- D. Candles for illuminating wires.
- E. Slate to which collimators are bolted.
- F & G. Wires in collimators.

Furthermore, the lenses are so adjusted that the two lines, the one of which is that proceeding from the centre of the collimator F to the centre of the lens *a*, and the other that proceeding from the centre of the collimator G to the centre of the lens *b*, shall be parallel to one another.

This condition is fulfilled in the following manner:—A telescope having an object-glass sufficiently large to embrace at once the two collimators *a* and *b*, is focused by means of a star for an object infinitely distant. It is then used as an instrument wherewith to view these collimators previously illuminated; if they appear in focus, it follows that they are to be optically regarded as infinitely distant bodies, and thus that they are accurately at the principal foci of their respective lenses.

In the next place, things are so adjusted that the vertical collimator shall appear to bisect the cross-wire collimator in the field of view of

the telescope. This adjustment is one which, from the form of the two collimators (a straight line and two cross lines), can be made with great exactness, and when accomplished, it follows that the two collimators, F and G, are to be optically regarded as two infinitely distant bodies, both being in the same direction.

Each of the two collimators has a moveable cover, so that, if desirable, the one can be viewed without the other.

The collimator lines are illuminated in the following manner:—These lines are formed of fine glass threads, and the light of candles symmetrically disposed is allowed to fall upon these threads. By this arrangement the threads are rendered luminous on both their sides at the same time; there is therefore no perceptible parallax, such as would follow from the one side of the thread being lit up at one time, and the other at another time.

It is now necessary to describe the method of fixing the collimators.

A brick erection was made in the basement hall of the Observatory, having the shape of a circular arc. To the flat top of this erection three pieces of slate, all in one horizontal plane, and having their upper surfaces curved, were attached by cement; finally, a slate slab, E (shown in the figure), was laid so as to rest simultaneously on these three curved surfaces. The collimators, being intended to rest on this slate slab, had their lower surfaces made quite flat, and were firmly bolted by means of screws to the slab.

The angular distances between the collimators are (roundly speaking) as follows:—

From 1 to 2	30°
„ 1 „ 3	60°
„ 1 „ 4	105°
„ 1 „ 5	120°

A horizontal table, B, capable of motion, either vertically or in azimuth, and also capable of being rigidly fixed in any required position, is placed in the centre of the circle of which the boundary line of the slate slab constitutes the circumference.

In order to determine accurately the angular distance between the various collimators, a theodolite is placed on the table B, so that when levelled its telescope, as it sweeps round in azimuth, may be able to bring into the middle of its field of view the various collimators.

No care need be taken that the centre of the theodolite is precisely in the centre of the circle, because the collimators being virtually at an infinite distance, it follows that the angular distance between any two of them does not depend on the exact centering of the theodolite.

Now, if any theodolite be taken, and if a number of sets of observations of the angular distances between the collimators be made, each set starting from a fresh point in the azimuth circle of the theodolite, it

is evident that by this means we shall eliminate any error of graduation of the theodolite.

A complete set of determinations of these angular distances ought, therefore, to refer to at least three starting-points in the horizontal circle of the theodolite, these being, say 120° , apart from each other.

The following complete sets have been made at various dates by Mr. G. Whipple:—

Measurements of the Angles between the Collimators of the Apparatus for the Verification of Sextants.

The measurements were made with a 6-in. Theodolite, divided to $30''$.

TABLE I.

Angles between collimators.	Dates of Observation.				
	Nov. 23, 1866.	Nov. 26, 1866.	Feb. 27, 1867.	May 2, 1867.	Means.
Nos. 1 and 2 ...	$\begin{smallmatrix} 0 \\ 29\ 59\ 44\cdot4 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 29\ 59\ 35\cdot0 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 29\ 59\ 45\cdot0 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 29\ 59\ 26\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 0 \\ 29\ 59\ 37\cdot8 \end{smallmatrix}$
„ 1 „ 3 ...	$\begin{smallmatrix} 59\ 59\ 31\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 59\ 59\ 41\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 59\ 59\ 46\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 59\ 59\ 29\cdot3 \end{smallmatrix}$	$\begin{smallmatrix} 59\ 59\ 37\cdot3 \end{smallmatrix}$
„ 1 „ 4 ...	$\begin{smallmatrix} 105\ 0\ 1\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 105\ 0\ 1\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 104\ 59\ 41\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 104\ 59\ 46\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 104\ 59\ 52\cdot9 \end{smallmatrix}$
„ 1 „ 5 ...	$\begin{smallmatrix} 120\ 0\ 11\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 120\ 0\ 11\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 119\ 59\ 56\cdot7 \end{smallmatrix}$	$\begin{smallmatrix} 119\ 59\ 53\cdot3 \end{smallmatrix}$	$\begin{smallmatrix} 120\ 0\ 3\cdot3 \end{smallmatrix}$

TABLE II.

Differences from Means.			
$\begin{smallmatrix} +0\ 6\cdot6 \\ -0\ 5\cdot6 \\ +0\ 8\cdot8 \\ +0\ 8\cdot4 \end{smallmatrix}$	$\begin{smallmatrix} -0\ 2\cdot8 \\ +0\ 4\cdot4 \\ +0\ 8\cdot8 \\ +0\ 8\cdot4 \end{smallmatrix}$	$\begin{smallmatrix} +0\ 7\cdot2 \\ +0\ 9\cdot4 \\ -0\ 11\cdot2 \\ -0\ 6\cdot6 \end{smallmatrix}$	$\begin{smallmatrix} -0\ 11\cdot1 \\ -0\ 8\cdot0 \\ -0\ 6\cdot2 \\ -0\ 10\cdot0 \end{smallmatrix}$

TABLE III.

Angles between Collimators.	
Nos. 4 and 5	$\begin{smallmatrix} 0 \\ 15\ 0\ 10\cdot4 \end{smallmatrix}$
„ 1 „ 2	$\begin{smallmatrix} 29\ 59\ 37\cdot8 \end{smallmatrix}$
„ 3 „ 4	$\begin{smallmatrix} 45\ 0\ 15\cdot6 \end{smallmatrix}$
„ 1 „ 3	$\begin{smallmatrix} 59\ 59\ 31\cdot7 \end{smallmatrix}$
„ 2 „ 4	$\begin{smallmatrix} 75\ 0\ 15\cdot1 \end{smallmatrix}$
„ 2 „ 5	$\begin{smallmatrix} 90\ 0\ 25\cdot5 \end{smallmatrix}$
„ 1 „ 4	$\begin{smallmatrix} 104\ 59\ 52\cdot9 \end{smallmatrix}$
„ 1 „ 5	$\begin{smallmatrix} 120\ 0\ 3\cdot3 \end{smallmatrix}$

It will be seen from Table II. that the observational differences from the means are extremely small, and capable of being accounted for by the uncertainty of reading a theodolite graduated to $30''$. We may therefore suppose the positions of the collimators to have remained the same throughout the period embraced by our observations.

In conclusion, it may be desirable to describe in a few words the method by which a sextant may be verified by means of this apparatus.

Let us suppose the collimators to be accurately and quite immoveably fixed, and the angular distances between them to be accurately determined. Also let the distance between the two lenses a and b of any collimator be such that the collimator F may be seen through a at the horizon-glass, and the collimator G through b at the index-glass of an ordinary sextant placed on the table B.

In order to test the index-error of a sextant, the vertical line of a collimator is made to bisect the cross lines belonging to the same collimator in the field of view of the telescope of this sextant. If the sextant is accurate, it should read *zero*, since these two lines are infinitely distant and in the same direction.

The sextant is next placed with its horizon-glass receiving the rays from the vertical line collimator F_4 (G_4 being covered), and its index-glass receiving the rays from the cross line collimator G_5 , and the telescope arm is moved until F_4 bisects G_5 in the field of view; if the instrument is correct, the reading ought to be (by Table III.) $15^\circ 0' 10''\cdot 4$. By pursuing this method it is evident from Table III. that the error of graduation of the sextant may be determined at every 15° of its arc.

In conclusion, it ought to be mentioned that perhaps no artificial light easily obtainable is sufficiently powerful to allow of the darkest glasses of a sextant being examined, and that for this purpose we may ultimately have to resort to other means.

II. "On the Observations made with a Rigid Spectroscope, by Captain Mayne and Mr. Connor, 2nd Master of H.M.S. 'Nassau,' on a voyage to the Straits of Magellan." By J. P. GASSIOT, F.R.S. Received May 25 and June 3, 1867.

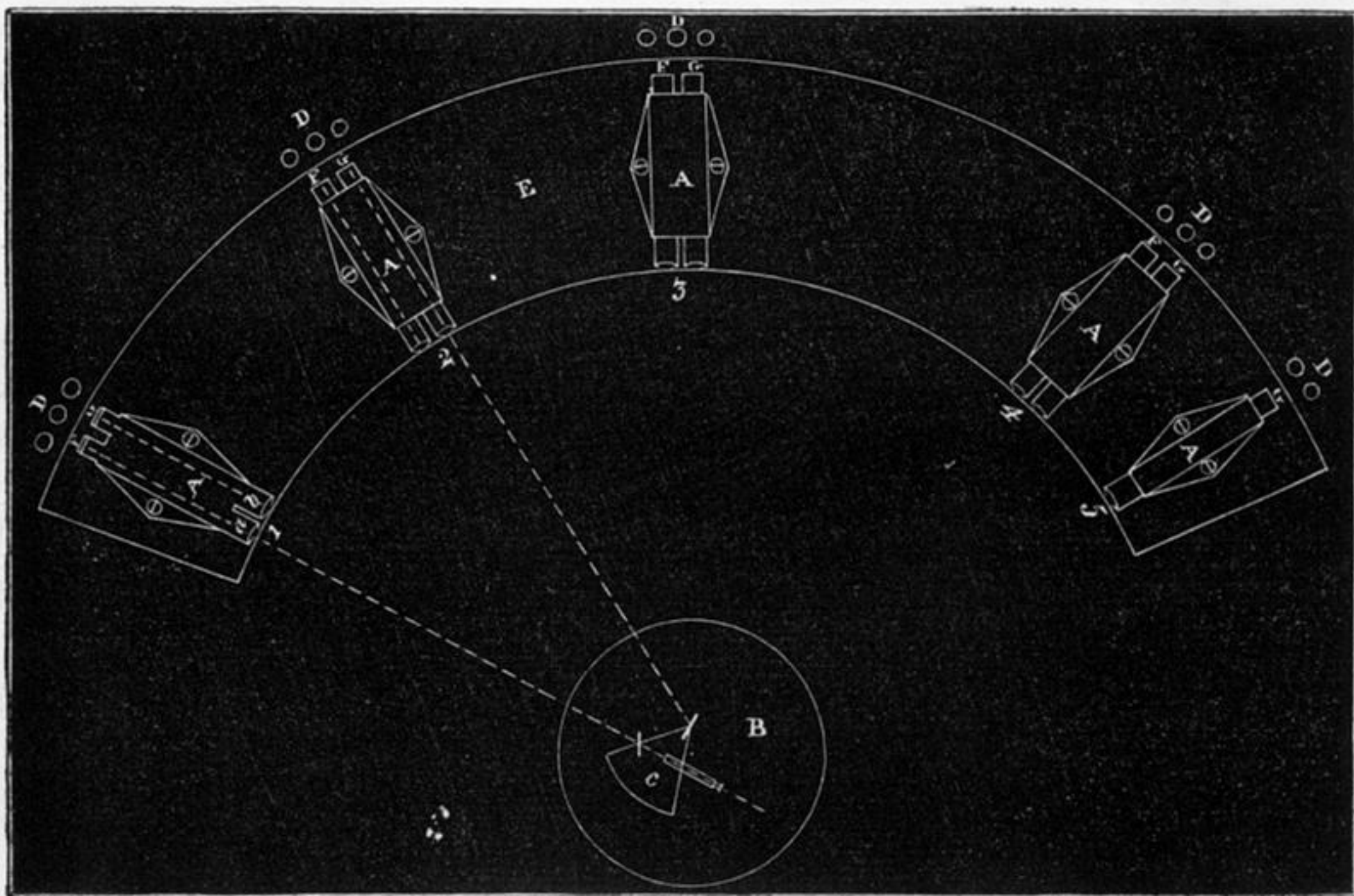
In a communication I made to the Royal Society on the 18th of May 1865 (Proceedings, vol. xiv. page 320), I described the rigid spectroscope which, at the suggestion of Mr. Balfour Stewart (in connection with a plan jointly conceived by Prof. Tait and himself), I had had constructed, the object sought being to determine by observation whether the index of refraction does not vary with the coefficient of terrestrial gravity, for which purpose it was thought desirable that the observation should be entrusted to some officer on board one of H.M. ships visiting various latitudes on both sides of the equator.

Through the kindness of Captain Richards, Hydrographer to the Admiralty, I obtained an introduction to Captain Mayne, of H.M. Ship 'Nassau,' at that time (August 1866) fitting out at Woolwich, preparatory to making a survey of the Straits of Magellan, and by appointment with Captain Mayne I visited the 'Nassau' in company with Captain Richards.

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